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(54) Title of Invention

LASER ANNEAL APPARATUS

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Specification

1.Title of the Invention

LASER ANNEAL APPARATUS

2.Scope of Claim

In a laser anneal apparatus equipped with a surface observation mechanism,

the apparatus comprises an observing lens system, an image transfer lens system, a lens system that is used for converging laser light and correcting a focal point ;

an image forming point which forms a transferred image of a sample is formed between said observing lens system and said image transfer lens system ;

the laser anneal apparatus being characterized in that a wavelength selecting plate is inserted between said observing lens system and said image transfer lens system so that the laser light and visible light are split and synthesized.

3.Detailed Description of the Invention

[Summary]

With regard to a laser anneal apparatus, the purpose is to provide a laser anneal apparatus capable of utilizing an objective lens with a short focal distance and high magnification by shortening the interval between the objective lens and a sample.

In a laser anneal apparatus equipped with a surface observation mechanism, it has an observing lens system, an image transfer lens system, and a lens system that is used for converging laser light and correcting a focal point. It is constructed so that an image forming point which forms a transferred image of a sample is formed between said observing lens system and said image transfer lens system, and a wavelength selecting plate is inserted between said observing lens system and said image transfer lens system, thereby splitting and synthesizing laser light and visible light.

[Industrial Field of the Invention]

This invention relates to a laser anneal apparatus and specifically, relates to a laser anneal apparatus equipped with a surface observation mechanism in which the surface of a sample in a minute area is observable specifically.

The laser anneal apparatus equipped with the surface observation mechanism observes the surface state of an object to be processed at the same time conversing laser light and irradiating the object to be processed. In recent years, devices with a laminated structure were invented as technologies to raise the degree of integration of IC and LSI, and one of them is SOI technology. There is a laser recrysrallization method as one of this SOI technology. This laser recrystallization method carries out melt recrystallization of a semiconductor layer with a non-single crystal by irradiating laser light at the semiconductor layer (for example, a poly Si layer) of the non-single crystal formed on an insulating film. The equipment utilized at this time is the laser anneal apparatus.

It is necessary to recrystallize, observing the surface of the semiconductor layer at the time of melting in order to improve crystallinity of the recrystallized semiconductor layer which is melted and recrystallized. A laser anneal apparatus is therefore, needed which can recrystallize while observing the surface.

[Description of the Related Art]

Fig.3 is a schematic diagram of an apparatus showing a constitution example of a conventional laser anneal apparatus.

In this diagram, 1 is an ocular lens, 2 is a total reflection mirror, 3 is a two wave length selection plate called a dichroic mirror (A dichroic filter may be used. However, in this case, parts reflected or transmitted by the dicroic mirror 3 are transformed into a system transmitted or reflected conversely. In this system, the aspect and position of the objective lens 5 is rotated 90 degrees and move to upper left in the drawing.) 4 is laser light, 5 is a converging lens that can function

as an objective lens. A is a focal point of the converging lens 5, B is a condensing position of the laser light 4, X is a deviation between the focal point A of the converging lens 5 and the condensing position of the laser light 4.

This conventional apparatus is to irradiate a sample (though not shown here, it is an object to be processed.) by selecting the wavelength of the laser light 4 with the two wavelength selecting plate 3 and converging the laser light 4 with the converging lens 5, and using the converging lens 5 as an objective lens enabled to observe the change of the state on the surface of the sample. However, in this apparatus, the deviation X between the condensing position B of the laser light 4 and the focal point A of the converging lens B (it means an observation position of a sample and the sample is usually arranged near a focal point of an objective lens in order to raise magnification) is easily produced because the laser light 4 oscillated from a laser oscillation pipe (not shown) has certain spread angle, thereby it was difficult to observe the surface of the sample at the focal point B of the laser light 4, which was a problem. Simply to shorten the deviation X here, in the drawing, if several lenses are prepared below the point B, the deviation X will become short as well as raise magnification at the time of observation. However, as the raised magnification, a focal depth at the time of observation becomes shallow (short), and after all, the surface of the sample will defocus at the time of laser irradiating.

As a method to solve the above problem, the following method can be considered. Hereafter, the method is explained using the drawings concretely.

Fig.4 is a schematic diagram showing another constitution example of a conventional laser anneal apparatus.

In this drawing, the same marks with the Fig.3 show the same or corresponding parts, and 11 is an objective lens, A' is a focal point of the objective lens 11, B' is a condensing position of the laser light 4, C is a focal distance of the objective lens 11.

In this conventional apparatus, the two wavelength selecting plate 3 is inserted between the objective lens 11 for surface observation and the sample (not

shown), and the laser light 4 condensed by the converging lens 5 is irradiated at the sample by the two wavelength selecting plate 3. This apparatus enables to conform the focal point A' of the objective lens 11 to the condensing position B' of the laser light 4. Specifically, the condensing position B' of the laser light 4 is suitably adjusted by changing the position of the converging lens 5 into the longitudinal direction like D in the drawing suitably. In other words, the interval between the focal point A' of the objective lens 11 and the condensing position B' of the laser light 4 can be suitably adjusted. In addition, the surface of the sample is set in a position where the focal point A' of the objective lens 11 conforms to the condensing position B' of the laser light 4.

[Problems to be Solved by the Invention]

However, in this conventional laser anneal apparatus shown in the Fig.4, the two wavelength selecting plate 3 should be apart from the sample in order not to give the effect of the heat on the two wavelength selecting plate 3 when, for example, the sample is heated about to 500 degrees C. Thereby, an objective lens with large magnification which has a short focal distance C of the objective lens 11 can not be used, therefore, the limit on magnification of the objective lens to be used arose, which was a problem. Specifically, the interval between the sample and the objective lens 11 should be apart approximately 5 cm. Thereby, the magnification of the objective lens is limited to 5 times, which means only for about 50 time magnification can be obtained even if the ocular lens has 10 time magnification. It can be expanded only for 2.5 mm square even if a laser irradiating field is 50 square. Substantially, about 200 time magnification is desirable.

Then, the present invention aims at offering a laser anneal apparatus that enables to use an objective lens with a short focal distance and high magnification by making an interval between an objective lens and a sample short.

[Means for Solving the Problem]

A laser anneal apparatus of the present invention is to achieve the above purpose, in a laser anneal apparatus equipped with the surface observation

mechanism, constituted so as to be equipped with an observing lens system and an image transfer system, and a lens system that is used for condensing laser light and correcting a focal point, to form an image forming point which forms a transferred image of a sample between the observing lens system and the image transfer lens system, to be inserted by a wavelength selecting plate between the observing lens system and the image transfer system, and to split and synthesize laser light and visible light in a laser anneal apparatus equipped with the surface observation mechanism.

[Function]

In the present invention, it is constituted so as to be equipped with an observation lens system, an image transfer system, and a lens system that is used for condensing laser light and correcting a focal point, to form an image forming point which forms a transferred image of a sample between the observing lens system and the image transfer lens system, to be inserted by a wavelength selecting plate between the observing lens system and the image transfer system, and to split and synthesize laser light and visible light.

Therefore, it enables to use an objective lens with a short focal distance and high magnification by making the interval between an objective lens and a sample short.

[Embodiment]

Hereafter, this invention is explained based on drawings.

Fig.1 is a schematic diagram of an apparatus showing a constitution of an embodiment of a laser anneal apparatus concerning this invention.

In this drawing, the same marks with the Fig.3 and Fig.4 show the same or corresponding parts, and 1a is an ocular lens (for example, f 25mm, ×10), 3a is a wavelength selecting plate called a dichroic mirror (it corresponds to a wavelength selecting plate concerning this invention), 4a is an Ar laser light for example, 20 is a half mirror, 21 is an objective lens (for example, f 42mm, ×5), 22 is a lens that is used for converging laser light and correcting a focal point (for example, f 100mm, ×10, and corresponds to a lens system that is used for

converging laser light and correcting a focal point concerning this invention), 23a and 23b are image transfer lenses (for example, 23a is f 20mm, ×4, and 23b is f 20mm, ×2, and corresponds to image transfer lens system concerning this invention), 24 is a sample, and 25 is observing light.

In addition, an image forming point of the objective lens 21 is the point M (it corresponds to an image forming point concerning this invention) here, and the image transfer lens 23a is suitably adjusted so that it forms an image at the point M. A point N is an image forming point of the image transfer lens 23b, and the image transfer lens 23b is suitably adjusted so that it forms an image at the point N on the surface of the sample. The laser light 4a has a function to process the surface of the sample 24. Moreover, the observing lenses (correspond to an observing lens system concerning this invention) are comprised of the ocular lens 1a and the objective lens 21.

Next, the principle of operation is explained.

Laser light 4a (for example, wavelength of 5145 Å, 10W) oscillated from a laser oscillation tube (although not shown here it is, for example, an Ar laser oscillation tube) has a certain spread angle, and the light that transmitted through a lens system 22 that is used for converging laser light and correcting a focal point is reflected by the wavelength selecting plate 3a (it reflects the light of 5154 Å here and the other light is made to transmit), and condensed at the point M by being reflected below in the drawing. Under this circumstance, a condensing position is adjusted so that it corresponds to the point M which is set beforehand by suitably moving the lens 22 that is used for converging light and correcting a focal point to left and right in the drawing (the point P). The light condensed at the point M is condensed again at the point N which is on the surface of the sample 24 by the image transfer lenses 23a and 23b, then process the sample 24.

When observing the surface of the sample 24, the sample image at the point N is transferred to the point M by the image transfer lenses 23a and 23b, and the transferred image of the image of the sample 24 which is transferred to

the point M may be observed through observing lenses (the objective lens 21 and an ocular lens 1a). Specifically, a part of the observing light 25 from an observation light source (not shown) is reflected downward in the drawing by the half mirror 20 and transmits through the objective lens 21. Then, this transmitted light is selected by the wavelength selecting plate 3a (for example, light except for 5145 Å is transmitted), subsequently transmits through the image transfer lenses 23a, 23b and irradiates the surface of the sample 24. On the other hand, the reflected light from the surface of the sample 24 transmits through image transfer lenses 23a and 23b, is selected by the wavelength selecting plate 3a, and transmits through the objective lens 21 and the half mirror 20. Then, it is reflected to the left in the drawing by a total reflection mirror 2, and transmits through the ocular lens 1a, which enables to observe the surface of the sample 24. At this time, the magnification at the time of observing is the product of the magnification of the ocular lens 1a, the objective lens 21, and the image transfer lenses 23a and 23b (10×5×4×2=400 times). The magnification of the typical observing lens is the magnification of an ocular lens × the magnification of an objective lens. Therefore, if the magnification of the objective lens 21 and the following lenses are considered to be the magnification of the objective lens in this embodiment, it becomes 5×4×4=40 times, which means that an objective lens with a short focal distance and high magnification is substantially used.

Namely, the above embodiment is constituted so that the image formation point (point M) which forms the transferred image of the sample 24 is formed between the observing lens and image transfer lens 23a, the wavelength selecting plate 3a is inserted between the observing lens and the image transfer lens 23a, and laser light 4a and visible light are split and synthesized. Hence, an advantageous effect equivalent to using an objective lens with a short focal distance and high magnification can be expected, thereby a minute area of the surface of the sample 24 can be observed.

In addition, the above-mentioned embodiment explained a case that the

wavelength selecting plate 3a is inserted between the objective lens 21 and the image forming point (the point M), and the laser light 4a and visible light are split and synthesized as shown in Fig.1. However, this invention is not limited to this, at least, the wavelength selecting plate 3a should be inserted between the lenses 23a and 23b of an observing lens and an image transfer lens, and as shown in Fig 2, it may also be a case that the wavelength selecting plate 3a is inserted between the image forming point (the point M) and the image transfer lens system 34 and laser light 4a and visible light are split and synthesized. In addition, image transfer lenses are not limited to two pieces, there is no limit of the numbers. In the meantime, in Fig. 2, 33 is an observing lens system.

Although the case which the wavelength selecting plate 3a is composed of a dichroic mirror is explained in the above-identified embodiment, the present invention is not limited to this and it may be composed of a dichroic filter.

[Effect]

According to this invention, the interval between an objective lens and a sample is made short, thereby it has an advantageous effect which enables to observe a minute area of a sample surface by using an objective lens with a short focal distance and high magnification.

[Brief Description of the Drawing]

Fig.1 is a schematic diagram of an apparatus showing a constitution of an embodiment of a laser anneal apparatus concerning this invention.

Fig.2 is a schematic diagram of an apparatus showing a constitution of another embodiment of a laser anneal apparatus concerning this invention.

Fig.3 and Fig.4 are schematic diagrams of an apparatus showing a constitution of an embodiment of a conventional laser anneal apparatus.

1a···an ocular lens

2···a total reflection mirror

3a···a wavelength selecting plate

4a···laser light

20···a half mirror

21···an objective lens

22···lens that is used for converging light and correcting focal point

23a, 23b···image transfer lenses

24···a sample

25···observing light